PUPILS' OUTLINES FOR HOME STUDY

IN CONNECTION WITH SCHOOL WORK

BOTANY

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BOTANY

SEEDS.

I. A Seed is a young plant in a resting stage, with food stored up to nourish the young plant until it is mature enough to take in organic food from the soil and atmosphere.

II. Origin of the Embryo.

A leaf folds together and forms a pistil which has an ovary inside. At some spot on the ovary, connected with a vessel bundle (vein) certain cells enlarge and subdivide forming masses of cells. These cells are at first all alike. A little later the outer layer forms the beginning of the seed coat and one or more of the cells inside enlarge and form the ova. One of the ova is fertilizd by a pollen grain from the anther forming an öosperm. The öosperm subdivides, forming many cells which make up the embryo. When the embryo reaches a certain size it stops growing and the seed has reached maturity.

III. Parts of a Seed are:

A. Seed Coat.
B. Embryo.
C. Food.

IV. Seed Coat.

The seed coat is often divided into two parts; the outer, harder coat called the Testa and the inner, softer coat called the Endopleurae. The endopleurae is often wanting. Sometimes a third coat grows.

V. Markings of the Seed Coat.

Hilum—the scar where the funiclus attached the seed to the ovary.

Micropyle—this is always found in young seeds where the pollen grain enters. In mature seeds it cannot be found on the outside. It closes up. It is found in the direction that the radicle points when the seed is open.

Chalaza—the point where the vessel bundles through which food passes into the seed, passed through the seed coat.

Rapha is formed by vessel bundles passing along the seed coat from the *hilum* to the *chalaza.*

VI. Parts Attached to the Seed Coat.

Attachments of the seed belong to the ovary, and hence are peculiarities of the ovary rather than the seed.

VII. Difference Between Fruit and Seed.

FRUIT is the whole ovary with its contents and whatever is attached to it. Some seed coats have peculiar markings as SPINES, CROSS LINES, etc.

VIII. Embryo—this shows great variety of form; the three parts are:—

A. Radicle or caulicle.
B. Cotyledons.
C. Plumule.

IX. Radicle is the beginning of the stem of a plant. From one end the root grows, and from the other the stem is continued. The part below the cotyledons is called the HYPOCOTYL, and the part above the EPICOTYL.

X. Cotyledons.

They are leaflike expansions on the sides of the radicle.

CONIFERAE—these may have more than two cotyledons; as, the hemlock, spruce, pine.

EXOGENOUS PLANTS are always dicotyledonous.

ENDOGENOUS PLANTS are always monocotyledonous.

In many plants, COTYLEDONS are simply organs of absorption for the purpose of absorbing the organic food in which they are imbedded.

In the grass family, the corn, wheat, etc., the single cotyledon is called the SCUTELLUM.

XI. Plumule.

It is a little bud which appears only in a few plants or seeds, but it always appears when the seed begins to develop.

XII. Food.

All seeds contain food enough to nourish the embryo, until it is able to build up organic food from ($H._2O.$) water and ($C._2O.$) carbondioxide.

This food may be stored in the cotyledons as in the bean. The seed is then said to be EXALBUMENOUS, or the food may be outside the embryo, as in the corn, wheat, castor-oil seed. It is then said to be ALBUMENOUS.

THE FOOD USUALLY CONSISTS OF:

1. Starch—a hydro-carbonate.
2. Aleurone—a proteid, containing Oxygen, Carbon, Hydrogen, and Nitrogen.
3. Oil—a carbo-hydrate. In some seeds it is found in such quantity that it is extracted for commercial use; as, in the flax, corn, cotton-seed.

A proteid is always present, but sometimes either the oil or starch is omitted.

ROOTS.

I. A Root is that part of the plant which is underground. This however requires modification; because *ROOTS* are frequently *not* in the *ground* at all, and because *stems* are frequently *underground.*

In a general way a root is that part of a plant whose function it is to take in liquid food and hold the plant in position; but even this definition needs to be modified to include all roots and exclude all stems.

II. Uses of Roots.

A. As Organs of Absorption.

Plants have two parts modified for the purpose of taking in food for the plant. These two are the leaves and roots. They are modified in very different ways, due to the difference in the kinds of foods absorbed.

For the absorption of gases, a broad, expanded surface is the best and consequently that is the way leaves are modified.

For the absorption of liquids, tube-like expansions are the most effective, consequently the roots are expanded in large cylinder-like roots with smaller cylinders, the rootlets; and fine thin-walled tubes, the root-hairs.

B. As a Means of Holding Plants in Position.

In many plants the use of holding them in position is more important than the function of absorption, particularly of plants growing in a moist atmosphere where the roots do not come in contact with the ground. These must be held in such a position that the leaves will come in contact with the sun. Some plants are held in position by long roots running downwards and other roots running at right angles to the first.

C. Function—A Store House of Food.

In many plants, particularly in those known as biennials, the root becomes a large swollen mass of plant food, made up principally of starch, sugar or proteids. Sometimes all three; as, in sweet potatoes, carrots, turnips, etc. The beet contains so much sugar that extracting it for general use has become an important industry of Germany and other parts of Europe and of the United States.

The food is stored up for the support of the plant during the season of reproduction when the plant flowers and goes to seed.

III. Distinction Between Roots and Stems.

The main root and the main stem form the primary axis of the plant.

A. Resemblances—They have many points of resemblance, being for the most part, bundles of vessels formed of cells modified—

1. To carry the material of which the food is made from the rootlets to the leaves.

2. To carry the manufactured food from the leaves to the different parts of the plant.

B. Differences—

1. The stem always has certain points of growth known as buds, the main stem growing from a terminal bud, and the branches from lateral buds.

Roots have growing points which grow into root branches, but those growing points are never buds, and are never protected by leaves, the root never bearing leaves.

IV. Position of the Root with Reference to the Stem.

1. The primary root is the main root growing from the seed. If there is one main root larger than the others this main root is known as the tap root. The branches of the primary root are frequently known as secondary roots, sometimes however this term is applied to roots that come from the side of the stem, as in the corn.

V. Position of the Root with Reference to the Ground.

1. **Subterranean roots** are those which grow in the soil.

2. **Aerial roots** are those which start above the soil and may grow into the soil or not. They hold the plant in place on some other tree or plant and absorb water which drops from the leaves and branches above.

Aerial rootlets are the little rootlets growing along the sides of certain stems as in the poison ivy for the purpose of attaching the plant to some support.

3. **Parasitic plants** usually have roots which imbed themselves in the roots and stems of other plants and draw their food supply from the host; as, the Mistletoe.

4. **Water Roots**—Some plants like the willow have roots suitable for either water or soil, while others like the water hyacinth are only adapted for water. They absorb the water through the whole epidermis, having no root hairs.

VI. Forms.

Roots are distinguished as:

1. **Fibrous**—roots in which the branches are numerous and nearly as large as the main or primary root; as, in the grasses, etc.

2. **Fleshy**—in which the root is very much larger than the branches and contains a large amount of stored up food; as, the turnip, carrot, beet, radish, etc.

FLESHY ROOTS ARE DISTINGUISHED AS:

A. Conical—parsnip.

B. Napiform—turnip-shaped.

C. Fusiform—spindle-shaped. Roots which taper towards both ends, as seen in some radishes and sweet potatoes.

D. Spherical—some turnips and radishes.

E. Irregular.

VII. Duration of Roots According to the Life of the Root.

1. Annual.

2. Biennial—do not produce seed until the second summer after they are planted. The first season produces the food stored in the roots.

3. Perennial—live for many years, the plant frequently dying to the ground in winter, but growing rapidly again the next year feeding on the food stored in the roots.

VIII. Structure.

Central Tube—containing larger cells for the passage of air and water, and smaller cells packed closely together to give strength and toughness to the root.

Cortex—the bark portion of the root.

Epidermis—the layer of cells forming a thin skin on the outside of the cortex.

Root Cap—simply a layer of cells covering and protecting the growing point. It is thickened by the addition of new cells on the inside while the old cells are rubbed off by the friction of the soil through which the root is advancing.

IX. Growth.

Roots can grow from a stem most anywhere if darkness and moisture be supplied. In growing they seek that part of the ground which has the most suitable temperature, the most moisture, and the least light, as they need the darkness. They are tough, to withstand pullings, but not having to withstand unequal side pressure as the stems, are not stiff.

STEMS.

I. A Stem is that part of a plant whose function it is to carry food material from the roots to the leaves, and the manufactured food from the leaves to the other tissues of the plant.

II. Function.

A. It is a circulatory organ and consists of a mass of circulatory vessels.

B. Another important function is to raise the leaves into such positions that they may receive the sunlight, because the whole life of the plant is dependent upon the energy which the leaves derive from the light.

III. Kinds of Stems.

A. Order of Growth.

Stems may be divided into a primary or main stem and secondary stems or branches.

B. Size and Amount of Wood.

Stems may be divided into *TREES, SHRUBS,* and *HERBS.*

A Tree is a plant which has one main stem containing a large amount of wood and which is of considerable size, usually much larger than any of its branches.

A Shrub is a plant with woody stems and two or more of the stems are of nearly the same size.

An Herb is a plant which has no woody stems and whose stems usually live but one year.

C. Length of Life.

1. Annuals—those living only one year.

2. Biennials—those living about two years.

3. Perennials—those living several years, in some cases centuries; as, the Mexican cypress living about five thousand years, and the California redwood trees, about two thousand years.

D. Direction of Growth.

1. Erect—growing nearly perpendicular.

2. Declining—bent at an angle.

3. Prostrate—lying on the ground.

4. Creeping—trailing along the ground.

5. Climbing—growing upward and supporting itself by means of tendrils which are modified leaves on stems or by rootlets produced above the ground along the stem in various places, as the English ivy.

6. Twining—growing upward and supporting itself by coiling around its support. It always twines the same way; as, the hop vine, but not all plants twine in the same direction as the hop species does.

E. Peculiarities of Structure.

1. Culm—a hollow stem usually with enlarged joints, as the stems of most grains; as, in the bamboo.

2. Sucker—one which starts from the root near the main stem and grows upwards; as, in the cherry.

3. Stolon—is a branch similar to a sucker but starts above ground and then bends down and takes root.

4. Runner—a long leafless stem which at the end takes root and then bears leaves.

5. Tendril—a leafless branch used for support; as the tendrils on a grape vine.

6. Spine—a leafless, sharp branch developed on some plants for protection.

7. Cladophylls—branches which are thin and flat and resemble leaves; as, the smilax.

F. Underground Stems.

1. Rhizome is the general name but stems which are modified because they contain a large amount of stored up food are usually spoken of as tubers or bulbs.

Tuber is a short, thick stem having buds called eyes, and composed almost entirely of stored up starch and proteid foods; as the potato.

Bulb is simply a terminal bud with very short, thick stems and with leaves and buds containing this stored up food.

According to the development of leaves, bulbs are distinguished as:

Solid Bulbs—those which have very rudimentary leaves.

Scaly Bulbs—those in which the leaves are scales; as, in the lily.

Coated Bulbs—those in which the leaves are well developed; as, in the onion, or hyacinth.

IV. Length of Stems.

This depends upon the distance which it is necessary to elevate the leaves above the ground in order that a particular species of plant may grow. They vary from the fraction of an inch as seen in the dandelion to many hundreds of feet as shown in the lianas of the South American jungles.

V. Parts of Stems.

Stems are divided into nodes and inter-nodes.

Nodes—points on the stem from which leaves and branches grow.

Internodes are the spaces between the nodes.

The *nodes* and *internodes* are very marked in the bamboo and other grass-like plants.

STRUCTURE OF STEMS.

The stem is filled with cells. The outside walls become thickened and towards the interior the appearance of the cells change. This modification of the cells depends on two functions:

1. To form a support for the leaves that they may get sufficient light and heat, as they are the organs of breathing.

2. To form a circulatory connection between the food supply in the root and leaves, and to transport this food to different parts of the plant.

ENDOGENOUS STEMS.

The outside cells are thick-walled and hard, but the other cells are thin-walled. These cells at certain irregular points have been modified so as to change their nature. At the tip end all the cells are alike. Cells grow and divide into several cells.

Meristematic Cells are those which have the power of producing new cells by subdivision.

Lasting Cells are those which have not the power to produce new cells by subdivision.

Tissue are many similar cells working together.

Parenchyma are cells which are not much longer than they are wide and containing practically no protoplasm. Their walls are thick as the wood cells. These cells help to give the stiffness and toughness to a plant.

ENDOGENOUS PLANTS.

In ferns and endogenous plants the vessel bundles form a considerable part of the whole stem. They are not arranged in rings but irregularly through the stem.

These vessel bundles do not enlarge as the plant grows. Within a short time they reach full size, due to the absence of a permanent cambium layer.

The arrangement of the phloem and xylem differs. In some plants the phloem is outside and the xylem inside; in others, there is just the opposite arrangement, while in the third set, they are placed side by side, as in the exogenous stems.

Function:—To carry up nourishment in the xylem, and to carry it down in the phloem.

EXOGENOUS STEM.

General Arrangement.

1. Central Cylindrical Tube of pith.

2. Woody Fibres—Xylem—in which the growth takes place as shown by the annual rings.

3. Cambium—Layer—that from which new wood cells are formed.

4. Bark—made up of bast, green layer, cork, and an outer covering.

The cells are regularly arranged in circles. At the beginning all the cells are *meristematic* or *peristematic;* but at certain points they are arranged in a circle, the cells divide across in two directions. This forms the *ground parenchyma.*

Pith is that portion of the original ground parenchyma which is inside the ring of modified cells. It is the *medulla.* Here is stored a large amount of food until the plant is mature, which may be for a long period.

Cortex is the layer of cells outside the pith, in which the growth takes place.

Cambium—layer is the middle of the ring; the inner side of which is the growing *wood cells or xylem* and the outer side of which is the *bark or phloem.*

Xylem are the lasting cells next to the pith, below the cambium layer. They are the woody parts as distinguished from the *bast or phloem,* the inner bark. The

inner cells of the xylem become prosenchymatic and meristematic, making the cells thick which at the beginning were long, thin ones. It is the fibro-vascular bundle containing tracheids or ducts with thick, yellowish walls.

(*a*) Wood-Fibre—The cells toward the center and outside undergo modifications not the same in all stems. The walls become thicker and form wood-fibres. The whole group of these modified cells of fibres and tubes is called a fibro-vascular bundle.

(*b*) Tracheids—Other cells become thickened in certain places only, the rest retaining their original thinness. This thickening takes place in different ways.

1. Annular Tracheids—walls of certain cells, ring after ring, are partly thick and partly thin. The thick ones for strength, the thin ones for the passage of the food supply.

2. Spiral Tracheids—cells are thickened in a band running as a spiral.

3. Pithed Tracheids—cells are thickened everywhere except at certain small places; pines, hemlocks, etc.

4. Scalariform—the cells are thickened along certain lines with the thin places across.

5. Irregular—many cells are classed under this head.

C. Ducts—Some cells of the xylem are modified for the purpose of carrying food from the root to the leaves. These break into other cells forming long tubes called ducts.

Sap is water, sugar, and proteid which comes down from the leaves through the inner bark and passes to the roots.

Phloem.

A. Bast is a slightly modified cambium cell. It is thin-walled to permit the sap to pass through.

B. Sieve Plates—two cells lapping over, forming a modified cambium tube is called a sieve plate. Those are found outside of the cambium and inside of the phloem. The sieve tubes of the inner bark carry the food from the leaves to the roots.

Sclerenchyma fibres are the thick-walled, long, slender cells making up the outer rind.

Vascular bundles are separated by Medullary Rays. These rays carry water and food across the stem.

Grafting—the process by which the cambium layer of one plant unites with a similar cambium layer in another plant and thus forms a single stem. This is done with fruit trees to secure fruit of certain flavor or color, etc.

- II. Fibro-vascular Bundle
  - A. Xylem
    - 1. Wood-fibre
    - 2. Tracheids
      - 1. Annual vessels
      - 2. Spiral vessels
      - 3. Pitted vessels
      - 4. Scalariform
      - 5. Irregular
    - 3. Ducts
    - 4. Parenchyma
  - B. Cambium
  - C. Phloem
    - 1. Bast
    - 2. Sieve Tubes
    - 3. Parenchyma

LEAVES.

A. Certain cells push out and form a flat layer of cells which grow close to the stem. These flattened masses are leaves, meristematic at first like the stem. Cells along the side divide; those which lap over the end are the terminal buds. These push up and give different stems which are closer together as we near the top.

B. The **Nodes** are places where the leaves come out, some are just *scars*, others are *joints*. The places between these are called the **Internodes.** The internodes grow during the first year, the leaves remaining at a constant distance.

C. When the leaves are formed certain cells are changed into vessel-bundles, forming a cluster of vessel-bundles which is the petiole, or stem of the leaf.

When the vessel bundles reach the blade of the leaf, they are known as veins or ribs, each is made of phloem and zylem for carrying water up and manufactured material down. They have a double function, that of transporting and supporting. They form the framework of the leaf.

D. Parts of the Leaf.

1. Petiole—stem leading to the blade of the leaf.

2. Stipules—attachments at the base of the petiole.

3. Blade—the skeleton of the leaf, ribs, veins, veinlets, and a large number of cells which are the same as the cortical cells of the stem.

The vessel-bundles of the stem of the leaf are a continuation of the vessel-bundles of the stem of the plant.

E. Structure of the Blade.

1. Top—There is a layer of epidermal cells covering the whole leaf. These are water proof, thus preventing the water which is in the leaf from evaporating. The top of each cell becomes thickened and is called the cuticle. Under the top epidermal

cells we find cells which vary in shape. They are longer, and are placed at right-angles to the surface of the leaf. These are called palisade cells from the regular arrangement. The protoplasm is colored green by chlorophyll; but this is found only in plants grown in the light.

2. Bottom—The same arrangement of cells is seen on the lower surface, as on the upper surface under the epidermis, but the cells are not so regular. There is usually more than one layer of cells. The epidermal cells are colorless and grow out into hairs which give a hairy surface. In the epidermis we have openings called stomas which lead into air cells—(great many more stoma in lower epidermis). These permit air to enter and vapor to leave. A stoma is protected by two kidney-shaped guard cells which control the size of the openings. Cells for the most part are irregular, and leave large openings in among the cells to admit the air from the stoma. All cells colored green are called mesophyll cells or cells of the middle leaf.

F. The Leaf.

It is an organ for taking in carbon di-oxide, and an organ in which food is manufactured.

G. Food.

Starches and proteids obtained from the roots through the vessel bundles, and carbon dioxide.

H. Arrangement of Tissue.

The pores are arranged so as to regulate respiration.

I. Parallel-Veined Leaves—veins arranged so that they run in the same general direction.

J. Net-Veined Leaves—veins extend in branches forming a net-work.

1. Palmately-veined—veins all start at one point and radiate; as, the palm leaf.
2. Pinnately-veined—veins run out from the mid-rib; as, the canna.

K. Arrangement of Leaves.

Broad leaves grow few in a row, while narrow leaves are close together and in many rows.

L. Forms of Leaves.

1. Linear—long and narrow.
2. Lance—broad.
3. Linear-Lance—between the two.

M. Margins.

1. Entire—smooth, unbroken.
2. Serrate—notched with teeth.
3. Dentate—notched with teeth outward.

N. Apexes.

1. Pointed.
2. Truncated.
3. Obtuse.

O. Bases.

1. Kidney.
3. Heart-shaped.
3. Oricular.

P. Surfaces.

1. Smooth.
2. Woody-covered with fine hairs.

Monocotyledonous plants generally have parallel-veined, smooth margin leaves. Dicotyledonous plants generally have netted-veined, notched margin leaves.

Q. Compound Leaves and Simple Leaves.

Leaves divided so as to have a number of blades growing from one vessel bundle is a compound leaf.

If a bud is at the base of a leaflet, it is a simple leaf because simple leaves have axle buds at the base of the petiole.

If the leaflets are arranged horizontally and do not have the buds at the base of each leaflet it is a compound leaf.

As the leaf reaches maturity, it stops growing, and produces more food which passes to the base of the leaf, making it thick-walled. The food supply then stops, and as the food cannot reach the leaf, it nourishes the bud which in time produces a branch.

R. Function of Leaves.

1. Give out oxygen.

2. Take in carbon dioxide,—given out by animals or by the burning and decay of any material.

3. Produce carbohydrates—sugar or starch by the union of carbon dioxide and water in the leaf when the light and temperature are suitable.

4. Respiration.

5. Assimilation—change food into materials of which the leaf is made.

6. Transpiration—giving off of vapor.

FLOWER CONSTRUCTION.

A **Flower** is a cluster of leaves modified for the purpose of reproduction.

In a COMPLETE FLOWER there are four rings or circles of these leaves. The two outer circles are for the protection of the inner circles. Flowers which do not have four circles are said to be INCOMPLETE.

Calyx-Sepal.

The outer circle forms the calyx, each leaf of which is called a sepal. The sepals are usually green.

Corolla-Petal.

The second circle forms the corolla, each leaf of which is a petal. These are frequently bright colored. When both the calyx and the corolla are of the same color, they are generally spoken of as the PERIANTH; as, the lily family.

Androecium-Stamens.

The third circle is formed of microsporophylls or leaves modified for the purpose of producing microspores. This circle is known as the androecium, each division of which is a stamen. The STAMENS consist of two parts, the FILAMENT and the ANTHER. The anther corresponds to the blade of the microsporophyl with the edges folded in, so as to form two megasporangia. Inside of these megasporangia are borne the microspores which are set free by the splitting of the edges of the sporangia.

Gynoecium-Pistil.

The inner circle consists of one or more megasporophylls, forming the gynoecium. The single megasporophyl or several united form the pistil. A gynoecium consists of one or more pistils.

In the angiosperms the megasporophyl is always folded so as to form a cavity. In this cavity are borne megasporangia. Each bears rows of seeds, six in each.

FLOWER CLUSTERS.

Flower Cluster is more than one flower formed upon a peduncle. These are given different names according to the arrangement of the blossoms on the peduncle.

A Raceme is a flower cluster in which each flower is borne upon a separate pedicel. The pedicels being of nearly uniform length and arranged along the sides of the peduncle; as, lily of the valley.

An Umbel is a flower cluster in which the flowers are borne upon pedicels of nearly uniform length and growing from the end of the peduncle; as, carrot.

A Corymb is a flower cluster in which the pedicels grow from the sides of the peduncle; but the lower pedicels are longer, so that the flowers stand nearly at a level; as, hawthorn.

A Head is a flower cluster in which the flowers grow on a short receptacle at the end of the peduncle, the flowers being sesil; as, red clover.

A Spike is a flower cluster in which the flowers grow on a long receptacle, on the sides of the peduncle, the flowers being sesil; as, plantain.

A Catkin is a spike which is tassel-like, and usually contains numerous modified leaves or bracts; as, willow.

A Spadix is a spike with small flowers crowded on a thick, fleshy receptacle. It is usually, but not always, protected by a bract called a SPATHE; as, Jack-in-the-Pulpit.

A Cyme is a general name for flower clusters in which a flower always terminates the peduncle and each of its branches; as, sweet William.

FORMATION OF SEEDS.

The embryo consisting of one stem, one or more leaves, is imbedded in the endosperm. This came from a fertilized ovum, which was fertilized by a pollen grain. Both the ovum and the endosperm were developed inside of a megaspore and formed a female prothallus.

The megaspore itself was developed inside of the megasporangia. The megasporangia first forming a mass of cells called neucellus, one of which grew into the megaspore and increased in size by feeding on the other neucellus cells.

The megasporophyll is a modified leaf which bears megasporangia. One or more megasporophyl forms the pistil of the flower. Each megasporophyl generally forms a separate cavity.

The pollen grains are produced from a microspore, and each pollen grain is a male prothallus consisting of two cells, one of which forms a pollen tube and the other forms the sperm.

The microspores are produced in the microsporangia which are formed by the infolding of the microsporophyll so as to form two cavities.

The microsporophyl is a modified leaf which forms the stamens of the flower. The stem of the leaf forming the filament and the blade forming the two cells or microsporangia.

FRUITS.

Fruit is the ripened ovary and whatever remains attached to it. Fruits are usually divided into three classes; SIMPLE, AGGREGATED, and MULTIPLE.

1. A Simple Fruit is one formed from a single pistil whether the pistil is simple or compound.

Simple fruits are usually divided into three divisions; FLESHY, STONE, and DRY.

A. Fleshy Fruits—the main kinds are the BERRY, PEPO or GOURD, and POME.

1. A **Berry** is a fleshy, simple fruit. It is soft and pulpy throughout; as, tomato, grape, gooseberry, current, etc.

2. A **Pepo** or **Gourd** is one having a hard rind and fleshy interior; as, the melon, cucumber, pumpkin, etc.

3. A **Pome** is an accessory, simple fruit in which the outside of the fleshy portion is formed from a calyx; as, the apple, pear, quince.

B. Stone Fruit or Drupe is one in which the outer wall of the ovary becomes fleshy, and the inner wall becomes a stone; as, the peach.

C. Dry Fruit is one in which the walls of the ovary do not become fleshy; as, akene, grain, nut, key, pod.

1. An **Akene** is a dry one-seeded fruit, in which the walls of the ovary become hardened and leathery.

2. A **Grain** or **Caryopsis** is a fruit in which the wall of the ovary is thin, and becomes closely attached to the seed.

3. **Nut** is a fruit in which the outer wall of the ovary becomes hardened into stone, and the inner wall becomes leathery.

4. A **Key** is like an akene with the addition of a wing.

5. A **Pod** is a fruit formed from the ovary and has the power of splitting open when mature.

II. An Aggregated Fruit is one formed from a number of pistils united, the pistils belonging to the same flower; as, the raspberry.

III. A Multiple Fruit is one formed from a number of pistils growing together, each pistil belonging to a separate flower; as, the pineapple or mulberry.

Anyone of these kinds of fruits may be accessory.

An **Accessory Fruit** is one in which some other part of the flower besides the ovary forms a part of the fruit.

SOME FOOD FOR PLANTS.

I. PARASITES—plants that obtain food entirely or in part from another plant or animal.

Those that obtain all their food in this way are not green; as, the dodder. Those that take some of the raw materials and from that prepare their own food always have green leaves; as, the mistletoe.

II. FLESH-EATING PLANTS—those that feed on insects which have been caught by a sticky fluid and frequently held by hairs, leaves, or coverings of the flower, until the digestible parts are absorbed; as, the Pitcher plant—Venus fly-trap.

SOME OF THE MEANS WHEREBY PLANTS ARE PROTECTED.

I. Plants having a dry, hard, or uneatable tissue are in this way protected from animals that would feed on the same were it juicy and tender.

II. Disagreeable taste or odor about a plant will protect it from animals; as, in the horse chestnut and tomato plant.

III. A. Thorns—as in the rose bushes.

B. Sharp pointed branches—as in the wild plum tree.

C. Sharp, stiff hairs—as in the prickly pear cactus.

D. Sharp saw-like edged leaves—as in the grasses.

All serve often to protect the plant.

IV. Ants frequently protect plants by feeding on the insects that would otherwise destroy them.

WEED.

This is any flowering plant which grows so profusely that it proves an annoyance by crowding out useful plants.

SOME USES OF VEGETATION.

I. Food for Man.

A. Grain—as wheat, oats, rye, barley, corn, rice.

B. Seeds—as peas, beans, peanuts.

C. Nuts—as cocoanut, chestnut, walnut, Brazil nuts, butternuts, pecans, hickory nuts, hazelnuts, filberts, beechnuts, almonds.

D. Coffee, Tea, Chocolate, Cocoa.

E. Fruits—dates, pineapple, banana, mulberry, fig, apple, quince, pear, plum, cherry, peach, apricot, nectarine, lemon, orange, grape, olive, melon, cucumber, squash, pumpkin.

Berries—cranberries, blueberries, huckleberries, strawberries, blackberries, raspberries, pepper, eggplant, tomato.

F. Roots, Bulbs, etc.—onion, carrot, beet, turnip, radish, artichoke, potato.

Sago, tapioca obtained from roots—sugar from beets or from the stem of the sugarcane.

II. Food for Animals—cattle, horses, and sheep.

A. Roots, Grains, and Bulbs used by people are fed to animals.

B. Grass, or dried as Hay—alfalfa, clover, corn, etc.

C. Some products remaining after manufacturing—linseed meal, cotton seed meal, refuse from breweries and from the manufacture of beet sugar.

D. Some seeds not used by man; as, acorns, beechnuts.

III. Fertilizer.

IV. Manufacturing.

A. Dyestuffs; as, Brazil wood, logwood, etc.

B. Varnishes—Japanese Lacquer from sumach family.

C. Tanning—bark of oak is used, etc.

D. Rubber—sap of tropical trees.

E. Flax, Hemp, Cotton and materials for thread and rope are made from the fibrous parts of plants.

F. Matting from sedges; baskets, hats, etc., from the straw of grains.

G. Panama Hats from fibrous parts of leaves.

H. Japanese Paper from bark of mulberry.

I. Cotton Cloth, Paper Pulp from spruce and poplar trees.

V. Timber.

VI. Fuel.

A. Coal—vegetable matter buried for centuries.

B. Peat—decayed bog mosses.

C. Wood.

D. Corncobs and Used Bark from tanneries.

VII. Ornament.

CARE OF FORESTS.

1. Only mature trees should be removed.
2. Prevent destruction by forest fires.

3. Exterminate destructive fungi.

4. Exterminate insects destructive to the trees.

5. Animals destroying young trees should not be pastured in woods.

6. Trees adapted to the soil and climate should be planted wherever the land can be spared for the purpose.

VEGETATION.

I. Determined by

A. Annual average temperature.

B. Extremes of heat and cold.

C. Winds.

D. Humidity.

E. Elevation.

F. Soil.

G. Rainfall.

II. Areas of Vegetation are known as

1. Tropical.

2. Temperate.

3. Arctic or mountainous.

III. Tropical Area of Vegetation.

1. Light—greatest amount found in this area.

2. Heat—greatest amount found in this area.

3. Moisture—

Very abundant in some sections, giving densely wooded regions; as, along the Amazon River.

Very scanty in some sections giving no vegetation only rocks and sand; as in the Sahara Desert.

Five degrees each side of the equator there are daily rains all the year round.

IV. Temperate Area of Vegetation.

The North and South Temperate Zones have similar plants.

Annuals, Biennials, Perennials, all can sustain life on the average amount of water.

Deserts in this area are not as large or destitute of vegetation as those in the tropics.

There are no such sections of luxuriant growth in this area as are found in the great forests of the tropics; but the greatest trees of the world, the giant redwoods of California are grown in this zone.

V. Arctic Area of Vegetation.

The plants are perennials. There are no trees, but the same species of plants grow as trees in warmer regions.

The part of the plant underground is much greater in proportion to the part that is above the ground and the flowers are very showy.

Mosses and lichens are abundant.

Mountainous Vegetation.

The ascending of a mountain effects vegetation in the same way that the Arctic sections do.

The plants have shorter stems, smaller leaves, more deeply colored flowers and larger roots than the same species of plant not grown on the mountains.

Timber Line is the highest altitude at which trees can be found to grow.

UNITED STATES.

United States lies in the north temperate zone and may be divided transverely into four sections.

I. East—Forest region with hardwood trees; as, the oak, hickory, beech, sycamore.

II. Center—Plain and prairie region, which for the greater part is treeless except along the streams—due to forest fires, scanty rainfall, and dry, severe winds in winter.

Grasses, golden rods, asters, sunflowers, and in the alkaline regions sagebrush is found.

III. Rocky Mountain Section—Mountain slopes, dense woods of evergreen trees, and alpine shrubs. In the South—cactus, yucca, and palm are found. Certain sections are desert due to the scanty rainfall and high temperature for long periods; as, seen in the Mohave Desert.

IV. Pacific Slope—In the South there is a dry and wet season. Vegetation develops rapidly in the wet season, but practically stops growing in the dry season. Here are found the great evergreen trees such as the sugar pine, yellow pine, giant redwood. In the North are the great evergreen trees and moss covered woods in which we find the red cedar, hemlock, spruce, and in places, maple, hazel, etc.

TRANSFERENCE OF POLLEN.

Some flowers are capable of producing seeds when self-pollinated, but many plants are entirely dependent on cross pollination to produce seeds.

Cross-pollination.

1. By Wind—especially pollen which is light and dry. Corn is best fertilized if the pollen is carried from the stamens of one plant, i. e., (tassels) to the pistil of another, i. e. (silk).

Plants depending on this method have pistils which are feathery and so adapted to catch flying pollen. Their flowers are regular and present no odor or bright colors.

2. By Insects.

Plants depending on this method usually have fragrant and bright colored flowers to attract the insects that carry away the pollen on their rough or hairy surfaces.

3. By Birds.

Plants depending on this method have flowers that have long tube-like shapes; as, canna, gladiolus, trumpet-creeper. These are visited a great deal by humming birds.

Pollen is protected from

1. Insects by a
   A. Sticky ring around the stem.
   B. Little pools of water at the point where the leaves join the stems.
2. Rain by
   A. Position of flowers—lily of the valley.
   B. Shape of flowers—tube too narrow for the rain to enter and some close in wet and open in dry weather.

PLANT KINGDOM.

It is divided into Thallophytes, Bryophytes, Pteridophytes, Gymnosperms, Angiosperms, but the last two may be grouped under the name of Spermatophytes.

1. Thallophytes.

This is the simplest kind of plant, usually consisting of a single cell, or series of cells, and is not divided into stems, roots, and leaves.

This division includes the algae and the fungi.

A. Algae—

This group contains more species than any other of the plant kingdom. They contain chlorophyll or some other coloring matter which changes water and carbon dioxide into food, mainly that of starch, for the plant.

1. Blue-Green Algae—(Cyanophyceae).

This is so called from the blue green pigment found in the cells. It has the simplest cell structure—growing by cells dividing rapidly throughout the body, there being no sexual reproduction.

It is found in fresh or salt, warm water, but it has been found in water as hot as 145 degrees (Yellow Stone Park).

2. Green Algae—(chlorophyceae).

In this class are several distinct groups, but in each there is sexual reproduction.

1. Zoöspores are sexual cells having hair-like cilia (two or four) which constantly flap up and down in the water causing the plant to move. These cells are developed in numbers in a mother cell called zoösporangium.

2. Gametes are the same in form as the zoöspore but have become by evolution eggs and sperms.

A. Eggs not having cilia have no motor power. They are usually large and well supplied with food.

B. Sperms have cilia and therefore have motive power. They are nearly colorless. The fusion due to the entrance of a sperm produces a fertilized egg or oöspore if it has a protective cell wall.

3. Brown Algae—(Phaeophyceae).

This is so called from the brown pigment which prepares food the same as the chlorophyll does in the other forms.

It includes sea weeds and is found in cold water along the coasts.

It is used as a fertilizer and from some rock weeds *iodine* is obtained.

Reproduction is of a higher order. The sperm enters the egg passing immediately to the center where the male and female nucleus fuse. If the egg now fertilized, finds a resting place it will germinate in twenty-four hours producing other plants.

4. Red Algae—(Rhodophyceae).

This is so called from the coloring matter found in the outer cells of the filaments where the food for the plant is prepared.

It is found in warm, deep water near shady rocks. It has a branching cord-like structure, the various filaments being held together by a jelly-like substance.

Reproduction—The sperm without cilia are developed in the small surface cells. At the ends of the branches are developed cells with long hairs for the reception of the sperm whose nucleus fuses with that of the female and after fertilization the hairs wither, and clusters of short filaments are formed, the terminal cells of which become spores and produce new plants.

There is alternation of generation as the sexual plant produces one that is sexual (spore bearing).

B. Fungi—

These contain no chlorophyll so cannot manufacture plant food but obtain their food instead, as parasites from plants or animals, or from decayed organic matter.

1. Bacteria—(Schizomycetes).

These are the smallest livings beings, made up usually of but one cell. These cells are arranged in chains or jelly-like masses, some of them being provided with cilia and so have motive power.

They are found all over, in the air, water, land, within and without people, animals, and plants. Some known as Germs and Microbes are very dangerous causing the spread of disease; some are harmless; while a third set, are of great benefit. The decay of matter is due to the action of bacteria.

Reproduction—They reproduce simply by a part breaking off. In a short time millions may be produced from the original cell.

2. Yeasts—(Saccharomycetes).

This class is larger than the bacteria and more complex having a nucleus.

Reproduction takes place by budding. Projections arise from the cells and increase in size until they are cut off.

Fermentation takes place by means of yeast; that is sugar and water is changed into alcohol and carbon dioxide. Bread is raised by the fermenting of the sugar in the dough due to the use of yeast, and the holes in the bread show where the carbon-dioxide and alcohol were forced out by the heat in baking.

3. Alga-Like Fungi—(Phycomycetes).

These are similar to algae in structure and reproduction. There are many kinds the most important being the Molds and Blights.

A. Molds are cobweb growths of branched filaments appearing white and sparkling from the many tiny drops of water on the surface. They are found on top of decaying matter, manure piles, or on bread decaying in a damp place.

Reproduction—The sexual organs are developed terminally and reproduction takes place by the ends of two short branches coming together uniting and then separating from the branches and becoming a sexual cell containing many nuclei of the two which fused in pairs.

B. Blights are parasites causing plant diseases; as, the potato blight or rot. Potato blight thrives best in cloudy, wet, and breezy weather. The green part of the plant withers and the potato rots in the ground. It may be carried over from year to year and spread so quickly that it causes famine in that section.

4. Sac Fungi—(Ascomycetes).

This class contains over fifteen hundred species, some of which are the Mildew, Cup, Knot or Wart Fungi.

Reproduction—They reproduce by spores—usually eight are developed in a sac and numerous sacs are found on one plant.

A. The Mildew is a white cobweb-like growth covering the leaves of the plant. Later in the season the black dots which are the sacs, appear.

B. The Cup Fungi are found on rotten logs in damp woods. Sometimes they are prettily colored and are as much as three inches in diameter. The inner surface of the cup is lined with sacs containing spores for reproduction.

C. Knot or Wart Fungi are found on the bark of trees and are black or brown.

5. Basidia Fungi—(Basidiomycetes).

There are nearly fourteen thousand species. The simpler basidia is divided into two main classes, Smuts and Rusts, while the more complex are divided into Hymenomycetes and other related ones which are again subdivided into many orders; as, toad stools and mushrooms; and the Gastromycetes with its related ones which are subdivided into many orders.

The group gets its name from the reproduction organ which is called *basidium*, meaning *pedestal*.

The Basidium is a terminal cell of a filament bearing four spores in a delicate stalk.

A. Smuts are parasites which attack the ovaries of members of the grass family and destroy the tissue of the host. This causes great loss in crops.

B. Rusts are parasites forming yellow or black spots on the leaves or the stems of the host which as a result becomes weakened and matures only a small quantity of grain.

C. Hymenomycetes—in these the spores are developed on the surface of the membrane and are exposed.

D. Gastromycetes—in these the spores are developed in cases and so are not exposed.

Lichen is a combination of algae and fungi. The algae preparing the plant food and the fungi furnishing moisture and protection. Lichens are found on rocks, branches of trees, and on ground where green vegetation could not live. They are found especially in subarctic regions where there is much rain.

II. Bryophytes.

This class includes those plants which usually have stem, leaves, and root hairs, but do not have vessel-bundles. It includes two classes; liverworts and mosses.

III. Pteridophytes.

This class includes those plants which have roots, stems, and leaves containing vessel-bundles; but do not produce seed. They are distinguished by having a life history, showing a well marked alternation of generation. It includes three classes; the ferns, the equicetae or horse-tails, and the lycopods or club mosses.

FERNS AND MOSSES.

Growing out from the epidermal cells, on the underside of the leaf are little cup-shaped spheres called *sporangia,* and these clusters form *sori.* Each of the sori are made up of thirty or forty sporangia, inside of which the *spores* are produced. A row of cells along the back are larger and thicker-walled than others and form a ring known as the annulus. The other cells are thin-walled, two of them are known as lip-cells. The lip cells open and throw out the spores, then evaporation takes place rapidly. The spores grow into *protonema.* Leaves have two functions, that of *respiration* and *reproduction.* Only a few ferns bear leaves having the two functions.

From the top of the moss, fine colored grains of dust called spores are shaken off, and fall on the dirt. They absorb moisture, carbondioxide and grow into a long thread, but form cross partitions making a chain of cells. This is green and spreads on the ground where the moss is going to grow. A little branch starts out on one side, called an end cell. It has the power of dividing in all directions.

The moss grows until it is about two inches, and becomes covered with leaves and sends down root hairs. In among the leaves of some mosses when in the mature stage, club-shaped organs known as spermium or antheridium are formed. The spermium becomes full of little cells known as sperm mother cells. Presently the top of the spermary breaks up and the mother cells escape and swim about. The mother cells are thin-walled containing sperms. The sperm has a head with a lash-like tail that divides into two parts.

On the head of another moss plant grows a flask-shaped organism called the *ovary* or *archegonium.* The lower end of the ovary is a mass of cells which absorb the others and become a large cell called the *ovum.* The large, lower end is known as the *venter,* and the other end as the *neck.* Inside of the neck the inner cells become mucilagenous and leave a passageway down to the ovum.

One of the male sperm unites with the female ovum, forming a fertilized cell immediately after which development takes place.

After fertilization the egg divides first in two parts, then four, etc. The lower cells push into the tissue and form what is known as the foot. This fastens into the top of the moss and becomes a parasite thus securing its moisture. It also pushes upward, tears off the venter and carries up the neck with it on an elongated stem. It continues to grow without leaves to a height of four inches. The cap, torn off the venter, has also green cells, so continues to grow. The *sporogonium,* is the spore-bearing part that grew on the four inch part. The egg in the head or stem grows up in a leafless stem with an urn or cup-shaped body at the end. At the front of this is a door, known as the *operculum.*

Over the whole thing is a remnant of the cap called calyptra, meaning veil, which was the wall of the ovary that was torn off. The cup falls off, the lid bursts open. Inside of the urn are spore cells. Around the rim of the urn are little rows of pointed cells known as teeth, for the purpose of protecting the spores. When it is dry or the teeth are disturbed they stand up and so permit the spores to escape but these teeth when folded in meet at a center. This very regular row of teeth is known as the *peristome.* The spores are not sexual (asexual) and this is the end of the history of the moss plant.

ALTERNATION OF GENERATION.

The production of a sexual plant known as the sporogonium.

1. Spore.
2. Protonema—thread (sometimes forms network over ground).
3. Moss Plant—bearing ovaries and spermaries.
4. Oosperm—which comes from the sporogonium.
5. Spore—Only two plants; all that comes from one spore is one plant.

The spore grows in a chain of cells called the protonema. This has a branch called a bud which produces a moss plant. This bears ovaries and spermaries either on one or two plants. The egg is fertilized by a sperm forming an oosperm. This is the life history of the first plant. (Gametophyte.)

The seed developed produces a moss plant. This sexual oosperm grows into a parasitic sporogonium which produces spores which grow into a protonema making the second moss plant. (Sporophyte.)

Gametophyte and sporophyte are independent plants.

The gametophyte is a small, simple, short-lived plant.

The sporophyte is a large, complex plant, with stem, roots, leaves, and a vascular system. It alternates with the gametophyte, the sexual generation, and is always fastened to it—being a parasite and so dependent on it for food and moisture; but after the earlier stages it becomes independent of the gametophyte.

Gametophytes are divided into microspores giving male prothalli and megaspores, the female.

FERNS.

1. On the leaves are the sori, which are clusters of spore cases called sporangia. In which spores are produced. After a time these are scattered by the breaking of the spore cases and falling on the ground, germinate. These differ from those of the moss, in having thickened walls which are not smooth, thereby producing various forms (triangular pyramids).

2. Germination of One Spore.

One spore on the soil germinates by taking moisture from the ground. It is green. It takes up starch and moisture and grows out in a chain of cells, the spore growing smaller. This is the protonema as in the moss. Almost at once the end cells divide longitudinally as well as transversely, and grow out so that we soon have a flat, leaf-like layer of cells. These soon divide longitudinally forming two cells thick. so that almost at once we have a flat, leaf-like or falloid mass of cells growing in the soil. This has an apical cell which does not grow as rapidly as the other cells. The protonema dries and disappears. The apical cell is protected by kidney-shaped cells having two-winged like projections. The flat cells send out root hairs and leaves by themselves.

3. Growth of Fern.

The prothallius corresponds to the moss plant, not to the protonema. It is a plant because it has reproductive organs. Growing on the underside, in among the root hairs or rhizoids, are little spermaries, imbedded in the tissue of the plants. The spermaries are little spheres full of sperms. They break open at the top and the sperms escape. These sperms are different from those of the moss. In the ferns they are also created for the purpose of locomotion. They are a spiral coil made of protoplasm, having cilia to enable them to swim.

On the under side of the prothallius, near the angle are less distinct cells imbedded in the tissue, forming the ovary. It is made of long cells, and has a canal in the center, and at the base of the neck is an expanded portion called the venter. In this is produced the ovum which is fertilized by a sperm coming down the neck, and forming an oösperm.

The oösperm divides and forms four cells. Each of these divides. One of the four original cells forms a projection which runs out into the prothallius and is called a Foot. Another of these cells grows into a root which extends down into the soil and grows. A third cell grows into a stem and the fourth one produces the first leaf on that stem.

In the ovary is the beginning of the fern plant. It is the most important part of the sporogonium. The prothallius is finally absorbed, leaving a withered leaf.

The stem in most of the ferns does not grow up in the air, but for a short distance in the ground, at the end sending up a bundle of leaves. These are annuals, but the stem continues to live year after year and each year sends up from its youngest part, that is the end just grown, a bunch of leaves. The main part of the underground stem only, is active; the older portion dies off and the branches become separate plants.

4. Cross-section of a Rhizone.

The cross-section of an underground stem is not exactly a circle, but has two well marked projections. On the outside is quite a layer of thick cells which correspond to the sclarenchyma in many higher plants. There are two crescent-shaped sclarenchyma cells around the center. These are not found in all ferns. In certain parts of the stem usually inside of the vessel bundle are the sclarenchyma cells. In the smaller vessel bundles they are scattered through the stem in circles, except two, which are found in the center.

The sclarenchyma cells are for the purpose of carrying sap. The rest of the space is filled in with thin-walled cells called parenchyma.

5. Vessel Bundles.

1. A vessel bundle consists of an outer row of cells called the bundle-sheath.

2. Inside of these is another row of cells called the phloem.

3. Inside of these is a third layer called bast, made of bast fibres.

4. Inside of these are many small bast cells which are called sieve tubes. These belong to phloem.

5. In the middle are large cells called scalariform thracheids which are long cells marked like a ladder. These cells have thick parts for strength and thin parts for nutrition. These form the Xylem. Inside of these are spiral tracheids.

6. Reproduction.

Sporophyls—leaves with spores. In most ferns the leaves have a double function, vegetative and to hold the spores. In some ferns, only certain of the leaves are sporophyls.

Sporangia—spore cases. In the fern, the spores are all alike in size. A spore produces always a prothallius, which is a flat, leaf-like structure. It is both male and female, containing spermaries and ovaries.

The ovary produces the ovum or egg, which is fertilized by the sperm and grows into the fern plant.

In some plants particularly in the Equisetum or horse tail, at the top of certain stems, sporophyls are arranged as cones.

The spores fall on the soil and produce prothallia; the smaller of which produce only spermaries, hence are male prothaliae, the larger of which produce ovaries, hence are female prothaliae. One kind of spore thus produces two kinds of prothallus.

In some of the Lycopods or club mosses, the sporophyls are arranged in cones. But these sporophyls produce two kinds of spores, one larger than the other. The

smaller ones are called microspores and produce rudimentary prothaliae which bear spermaries, these are the male prothaliae. The larger spores are called megaspores. The megaspore grows into a somewhat larger prothallus bearing ovaries. This is a female prothallus. Just before the fertilized ovum grows into the main plant we have a sporogonium.

On the pine tree near the top, just underneath the terminal bud of the plant are borne each spring a large number of sporophyls arranged as small cones, incorrectly called male cones. On the underside of each leaf are borne two sporangia. These are microsporangia.

The protoplasm divides up into microspore mother cells which grow into prothaliae. These cells divide into two parts, one larger than the other, each has a nucleus which produces a two-celled prothallus, called micro-prothallus. It does not get food for itself, as it has enough supplied to last it for life. It grew from a microspore so is a male prothallus. The pollen grain is a male prothallus. The development taking place in the sporogonia; which burst open and the pollen grains were scattered.

On the same or another pine tree, in the spring, appear certain modified leaves, incorrectly called female cones. These are quite small, no larger, at first, than the male cone. On the upper surface of the megasporangia or carpels there appear two megasporangia or spore cases which lie side by side. They each consist of one cell which divides into many cells with leathery coats surrounding them. The outer coat is known as the integumend. In the inner wall of the integumend at the inner end of the megasporangia is a small opening known as the micropyle. Within the integumend is the nucleus. At first all the cells in the nucleus are alike, soon one enlarges by eating the neucleus and becomes a thin-walled large cell. This is the ovary inside of which is the ovum. By and by the female prothallus eats all the neucellus and reaches the integumend.

A pollen grain is caught in the leaves of the cone which is now open. One grain is found near the micropyle, this is ready to fertilize the ovary, so passes down the tube until it reaches the ovum.

The neucleus passes down the spermary of the pollen grain which is elongated to the tube. Near the bottom the neucleus divides generally into two parts, each part being a sperm. These reach the ovary as described above, each sperm going to an ovum and we have an o-ösperm.

The o-ösperm divides, breaks out of the wall, sends out thread-like projections into the endosperm. These threads are known as suspensores, usually only one suspensore developes into an embryo.

The embryo has at the end away from the ovum one or more leaves, in the pine, eight; in the dicotyledons, two. The root end always points to the micropyle. The integumend becomes waterproof, as it grows older, a part of the epidermis of the leaf pulls off and forms a wing.

It takes two years for a cone to reach its full size. During the first year it is closed and pitch covers it. It turns over and hangs downward to prevent the rain from getting in. It remains so during the next fall and winter, then opens to let the seed out.

The Seed—the inner coat is a wall of a megaspore; the outer coat is a wall of megasporangia or integumend. All the starch and protoplasm is endosperm derived from megaprothallus.

If the plant kept on growing, no seeds would be formed. The leafs cut off the sap supply, they then become hard, the protoplasm dries up, and the plant is in a resting stage.

A SEED is an embryonic plant in a resting stage surrounded by a food supply.

IV. Spermatophytes—Seed Plants.

There are two great classes.

A. Gymnosperms—bear seeds which are exposed being borne on open carpels. This class is divided into the coniferae and the cycads.

They have well developed roots, stems, leaves. A single stem rises vertically from the ground with side branches which are almost horizontal and which taper towards the top of the plant. The leaves are either scales or needle-shaped and remaining on trees gives them the name of *evergreen*. There being so small a surface exposed by the leaves, the plant can stand extremes of heat and cold. They contain a large quantity of resin and turpentine which is a means of protection from attack by animals.

B. Angiosperms—bear seeds which are in closed carpels.

They have well developed roots, stems, leaves. This class is divided into MONOCOTYLEDONS and DICOTYLEDONS.

1. The **Monocotyledons** are distinguished by having an embryo with one seed leaf or cotyledon, and a growing point on the side; by having endogenous stems; by generally having parallel-veined leaves, which are seldom notched; and by having the parts of the flowers in three's or multiples of three or sometimes in four's.

This class is divided into three sub-classes; PETALOIDAE, SPADICIFLORAE, and GLUMNIFLORAE. These classes are distinguished by the kind of protective leaves which surround the stamens and pistils.

A. Petaloideae—the reproductive parts of the flower are protected by petals, and sometimes by sepals; as, in the tulip. It includes flowers belonging to the lily family, the orchid, the iris, the amarylis and a few other families.

B. Spadiciflorae—plants whose flowers grow on a thickened peduncle and are usually protected by a modified leaf called the *spathe*, the flower cluster forming a *spadix*. It includes flowers of the arum, cat-tail, palm, and few other families.

C. Glumniflorae—plants whose flowers are protected by modified leaves called *glumes*. These include the grass and sedge family.

2. Dicotyledons are distinguished by having embryos containing two cotyledons and a growing point at the end; exogenous stems; usually net-veined leaves which are notched and sometimes are divided or compound; and by having the parts of the flowers generally in five's but sometimes in four's.

PUPILS' OUTLINES

for Home Study in Connection with School Work

LIST OF PUBLICATIONS

American History, Part I
United States History, Part II
English History, Part I
English History, Part II
Ancient History, Part I–Oriental Nations–Greece
Ancient History, Part II, Rome
Mediaeval History
Modern History, Part I
Civics, Part I
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Civics of New Jersey
Geography, Part I, Countries of North and South America
Geography, Part II, Asia, Africa and Australia
Geography, Part III, Physical, Political Geography
Geography, Part IV, Commercial Geography
Geography, Europe
Geography, United States
Physics, Part I
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Business Forms.
Grammar
Botany
Arithmetic, Part I
Arithmetic, Part II
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